HEATH Co.

"PROPERTY OF:"
GENERAL ELECTRIC CO.
LOS ANGELES INSTRUMENTATION

Electronic Services - Los Angeles
M12937X

GENERAL ELECTRIC CO
Instrumentation & Control
228 W. Florence Ave.
Inglewood, Calif. 90301

SERVO RECORDER

Model

EUW-20A and EUW-20AE

EUW-20A

SERVICE INFORMATION

The following Heath Company services are available if you need them: Replacement Parts, Technical Consultation, and Factory Service. Address all correspondence to:

HEATH COMPANY
Benton Harbor, Michigan 49022

For prompt service, use a separate letter for each department you write to.

REPLACEMENT PARTS

If a replacement part is needed, please include the following information in your letter:

1. Part number and description.
2. Model Number and Series Number of the equipment.

If your equipment is in the Warranty period, add:

3. Date of purchase.
4. Nature of defect.

Heath Company will fill your order promptly. Please DO NOT RETURN PARTS unless they are requested. Parts that are damaged through carelessness or misuse by the customer will not be replaced without cost.

TECHNICAL CONSULTATION

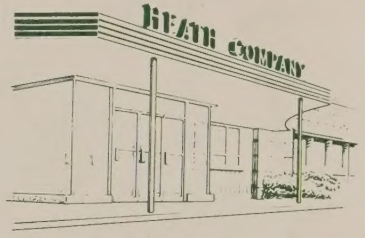
You can write to our Technical Consultants for help with any Heath equipment, or for answers to any questions about the use of this equipment.

The completeness and accuracy of the advice mailed back to you depends entirely on the information in your letter. Be sure to include:

1. The Model Number and Series Number of the equipment (on blue and white identification label).
2. Date of purchase.
3. An exact description of the difficulty. Include switch positions, connections to other units, operating procedures, voltage reading, and any other information you think might be helpful.
4. List everything you have done in attempting to correct the difficulty.

FACTORY REPAIR SERVICE

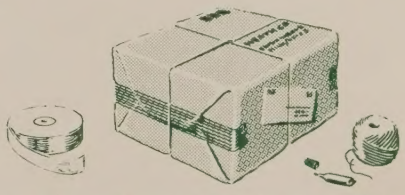
You can return your equipment to the Heath Company Service Department to have it repaired for a minimum service fee. (Equipment that has been modified will not be accepted for repair.) Refer to Shipping Instructions for details on how to package and ship the equipment.



To be eligible for replacement parts under the terms of the Warranty, equipment returned for Factory Repair Service must be accompanied by the invoice or the sales slip, or a copy of either. (If you send the original invoice or sales slip, it will be returned to you.)

SHIPPING INSTRUCTIONS

Check the equipment to see that all parts and screws are in place. Then, wrap the equipment in heavy paper. Place the equipment in a strong carton, and put at least three inches of resilient packing material (shredded paper, excelsior, etc.) on all sides, between the equipment and the carton.



Seal the carton with gummed paper tape and tie it with a strong cord. Ship it by prepaid Express or insured Parcel Post to:

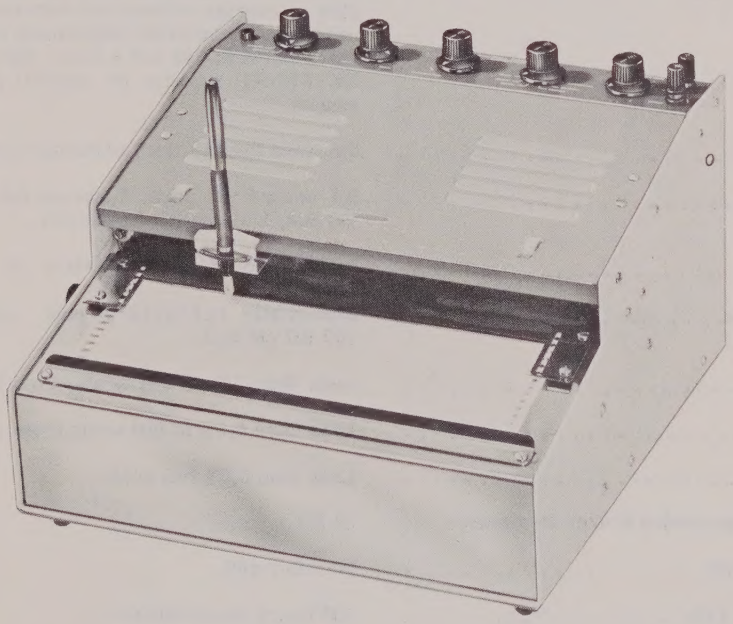
HEATH COMPANY
Benton Harbor, Michigan 49022

Attach a letter containing the following information, to the outside of the carton:

1. Your name and return address.
2. Date of purchase.
3. A brief description of the difficulty.
4. Your authorization to ship the repaired unit back to you C.O.D. for the service and shipping charges, plus the cost of parts not covered by the Warranty.

OPERATION OF THE HEATH SERVO RECORDER

MODEL EUW-20A and EUW-20AE



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HEATH COMPANY

BENTON HARBOR, MICHIGAN

595-789

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SPECIFICATIONS

Chart Paper	Grid Width: 10" Length: 120 foot roll. Markings: 0-100, right to left.
Chart Speed	2 inches per minute; additional motors for special chart speeds are available from Heath Company, see Page 20.
Chart Span	Five fixed ranges: 10, 25, 50, 100, and 250 mv; plus a vernier adjustment between each fixed range, which provides adjustment of span to any value between 250 and 3.3 mv. There is also an EXTERNAL position for special plug-in fixed ranges.
Pen	Standard fountain pen, cartridge type.
Balancing Time	0.1 second per inch, 1 second full scale (10"). (50 cps, 1.5 seconds full scale).
Input Circuit	Self-balancing potentiometric on all ranges.
Input Resistance	Essentially infinite at null. Approximately 500 KΩ off null.
Overall Error	Less than 1% of full scale from 10 to 250 mv.
Dead Zone	Less than 0.5% of full scale from 10 to 250 mv.
Linearity	Less than 0.5% full scale.
Maximum Recommended Source Resistance	50 KΩ.
Reference Source	Mercury cell.
Reference Cell Life	300 hours (approximately).
Accessory Sockets	10 watts may be drawn from each socket at 120 V AC. 10 watt total may be drawn at 240 V AC. 6.3 V AC at 50 ma may be drawn from the accessory 11-pin socket.
Power Requirements	120/240 volts, 60 cps; 45 watts. (120/240 volts, 50 cps; 50 watts.)
Fuse	1 ampere slow-blow.
Dimensions	13-3/4" wide x 8-3/4" high x 13-3/8" deep.
Net Weight	17 lbs.

INTRODUCTION

The new Heath Model EUW-20A Servo-Recorder offers several unique features found in no other unit. In normal operation it is a precision laboratory-type self-balancing potentiometric recorder which can be used to record pressure, speed, temperature, strain, pH, light radiation, and many other phenomena when connected to suitable signal sources. It is also easily modified for multi-purpose applications as a servo system. It can be quickly connected for use as a servo constant-current source, a self-balancing Wheatstone bridge, an integrating recorder, a recording microammeter, and other servo-devices.

Three 5-pin plugs enable rapid modification for use in a new research and development problems requiring a sensitive, fast response, recording servo system. Experimental circuits can be connected in a few minutes by using the spring-clip parts from the EU-13A Universal Chassis and Parts kit.

Provision is made for remote operation of the Recorder. An 11-pin accessory socket and two standard 120 volt power sockets are on the side of the Recorder, as shown in Figure 1. The starting and stopping of other instruments can be synchronized with the SERVO and CHART positions of the Power switch. Also, the Recorder can be operated by remote switching from another instrument.

The unique layout and connector system in this unit enable servo solutions to research and development problems to be quickly tested and put to use. The EUW-20A is truly a multi-purpose instrument. In addition to its use as a precision measurement and control device, it serves as an ideal educational unit for learning about servo mechanisms.

The use of standard, easily obtained cartridge-type pens makes it possible to obtain multi-color plots merely by changing the pens. The special standby circuit conserves the limited-life components in the Recorder, such as the mercury reference cell and chopper, by switching them out of the circuit when not recording. The impedance reduction damping feature of the Recorder makes it possible to introduce damping into the servo system without appreciably increasing the dead zone. Optional, easily-changed chart speed motors are also available.

THE MALMSTADT-ENKE INSTRUMENTATION LABORATORY

This instrument is one of the units included in The Malmstadt-Enke EU-100A Instrumentation Laboratory. It is available as an individual unit, or it can be purchased at a special group price when included with the total EU-100A system. The units of the complete EU-100A Laboratory Station are useful not only in learning electronic concepts, but also in research and development, and control instrumentation.

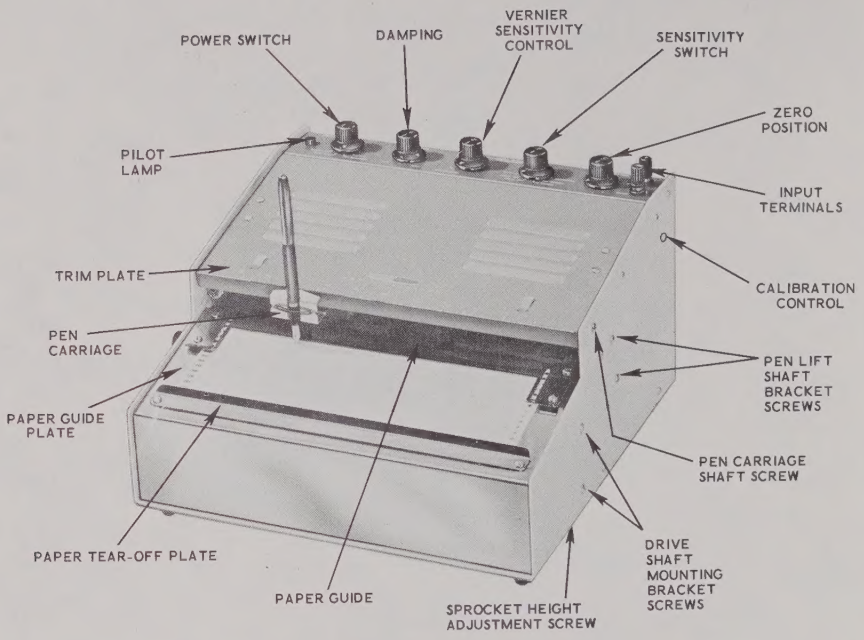


Figure 1A

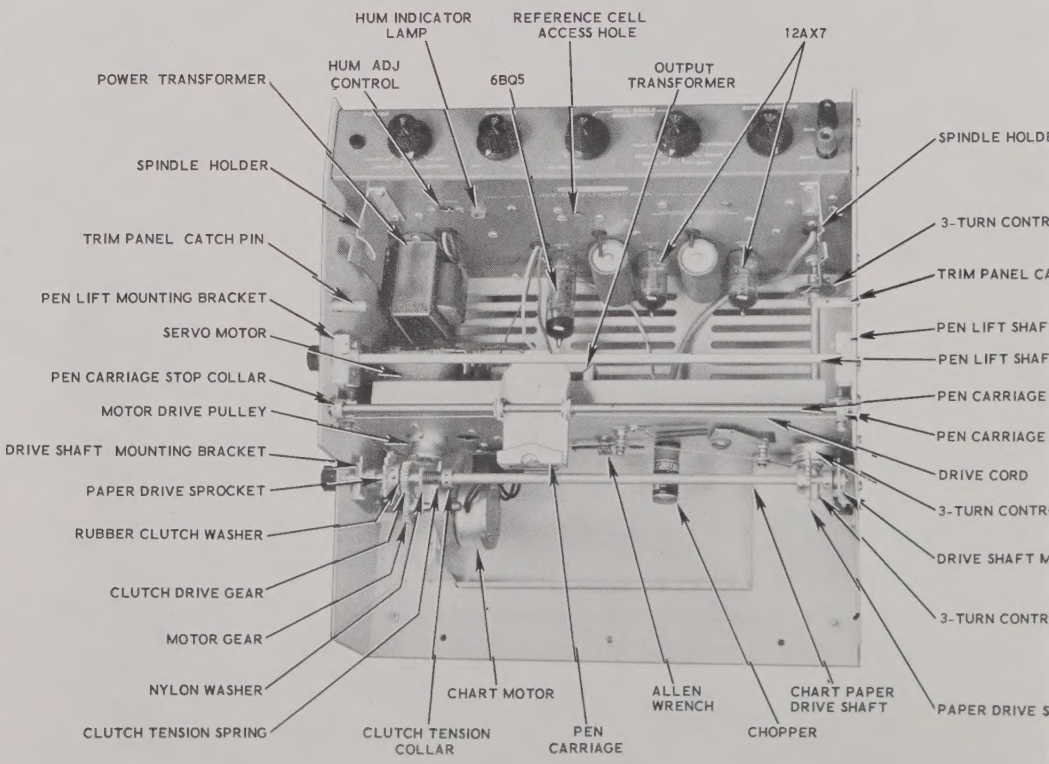


Figure 1B

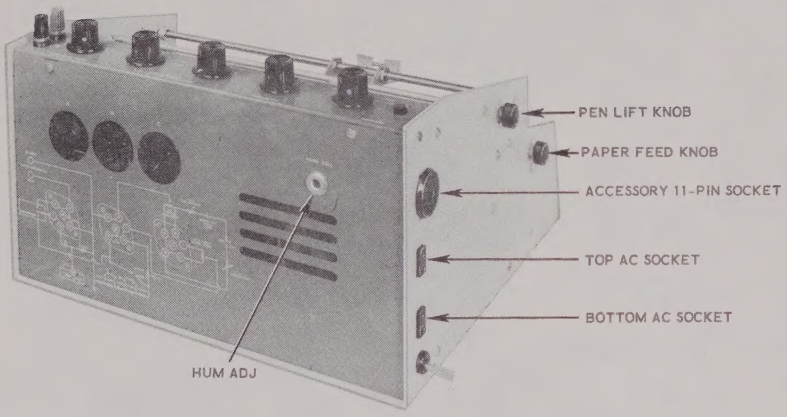


Figure 1C

OUPLING

PIN

UNTING BRACKET

T

COLLAR

RIVE PULLEY

TING BRACKET

XTENSION SHAFT

KET

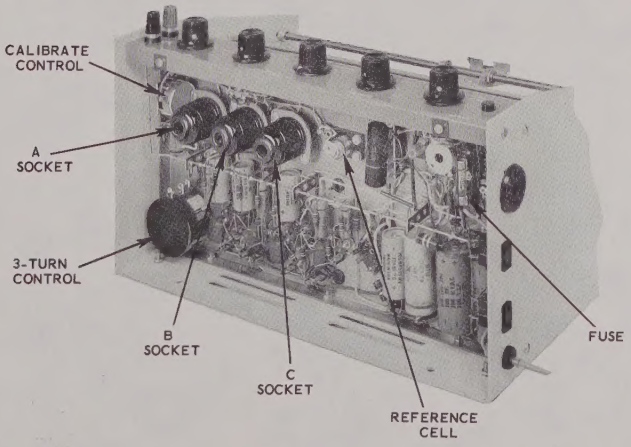


Figure 1D

OPERATION

CONTROLS AND INPUT TERMINALS

Before operating the Recorder, read the following information to familiarize yourself with operation of the controls. Refer to Figure 1.

POWER SWITCH

OFF. . . All power is disconnected, including the reference cell.

STANDBY. . . Only the filament voltage and B+ voltage to the voltage amplifiers are turned on. Power to the chopper, servo motor, and chart motor is disconnected; the reference cell is also disconnected. This is the position normally used for initial setup of the Recorder. This position is also used when the Recorder is operated at intervals and kept ready for instant use. 120 volts AC is available at pins 1 and 2 and 6.3 volts AC is available at pins 9 and 10 of the 11-pin accessory power socket.

SERVO. . . In this position, the reference cell, 120 volts AC to the servo motor, B+ to the power amplifier for the servo motor, and 6.3 volts AC to the chopper are all connected. This allows the Recorder to be zeroed and calibrated without the chart paper moving. In this position, the bottom AC socket is switched on; 120 volts AC is applied to pins 1 and 3, and 6.3 volts AC to pins 9 and 11 of the 11-pin accessory power socket.

CHART. . . In this position, the chart motor is turned on, as well as the SERVO position functions, and the chart paper moves through the Recorder. The top AC socket is turned on in this position and 120 volts AC is available at pins 1 and 4 of the 11-pin accessory power socket.

DAMPING CONTROL

The DAMPING control adjusts the output impedance of the power amplifier by varying the amount of feedback. Increasing damping just to the point that prevents excessive overshoot or oscillation of the marking pen provides greater control over the servo motor and, therefore, maximum accuracy. The DAMPING control must be readjusted each time the span is changed.

FULL SCALE SENSITIVITY CONTROLS

The Sensitivity switch along with the Vernier Sensitivity control determines the full scale sensitivity of the Recorder. The switch has five fixed positions and an EXTERNAL position. In the EXTERNAL position, a voltage divider network can be used for special applications. See Applications on Page 7. In order to use the fixed sensitivity positions, the Vernier Sensitivity control must be fully counterclockwise.

The Vernier Sensitivity control allows adjustment of each fixed full-scale sensitivity position to increase the sensitivity up to one-third. For example, the 100 mv position can be increased in sensitivity to about 33 mv.

ZERO POSITION CONTROL

This control allows the zero point to be set at any position on the chart paper between zero and 100. To extend the range of the ZERO POSITION control, see ZERO SUPPRESS on Page 12.

INPUT TERMINALS

The black terminal must always be connected to the "low side" of the input signal being measured. The red terminal should be connected to the "high side" of the input signal. The wire connected to the red terminal may have to be shielded in some cases to keep high AC fields from entering the Recorder. This hum would be indicated on the chart paper by a large dead zone, and a bright glow of the Hum Indicator lamp during null balanced conditions. Adjustment of the HUM ADJ control will often counteract a moderate 60 cps input signal. A positive-going signal applied to the Recorder will cause the marking pen to scan from right to left. It is also possible to scan from left to right, as described under WIRING CHANGES TO REVERSE PEN TRAVEL on Page 11.

CALIBRATE CONTROLS

With the Calibrate control adjusted on one fixed sensitivity position, all other positions will be within 1% of full scale. For maximum accuracy, the Calibrate control can be adjusted for the particular position being used. NOTE: The Vernier Sensitivity control must be fully counterclockwise when calibrating the fixed sensitivity positions.

HUM ADJUST CONTROL

For initial hum adjustment, short the input terminals with a short wire. Place the Sensitivity switch in the 10 mv position and turn the Vernier Sensitivity control fully counterclockwise. Turn the HUM ADJ control for minimum glow of the neon Hum Adjust Indicator lamp. The HUM ADJ control is accessible from the rear or front of the chassis. See Figure 1.

The preceding adjustment will be adequate for most Recorder operations. If, after connecting the Recorder into a setup, the Hum Adjust Indicator glows brightly at null balance, it is indicating hum being applied at the input of the Recorder.

For maximum accuracy and minimum dead zone, the HUM ADJ control should be readjusted each time the sensitivity or the Recorder setup is changed. This should be done with the Recorder operating and at null balance.

PAPER FEED KNOB

The Paper Feed Knob is used to manually advance the chart paper.

PEN LIFT KNOB

The Pen Lift Knob is used to lift the pen from the chart paper. This can be done by turning the knob in either direction.

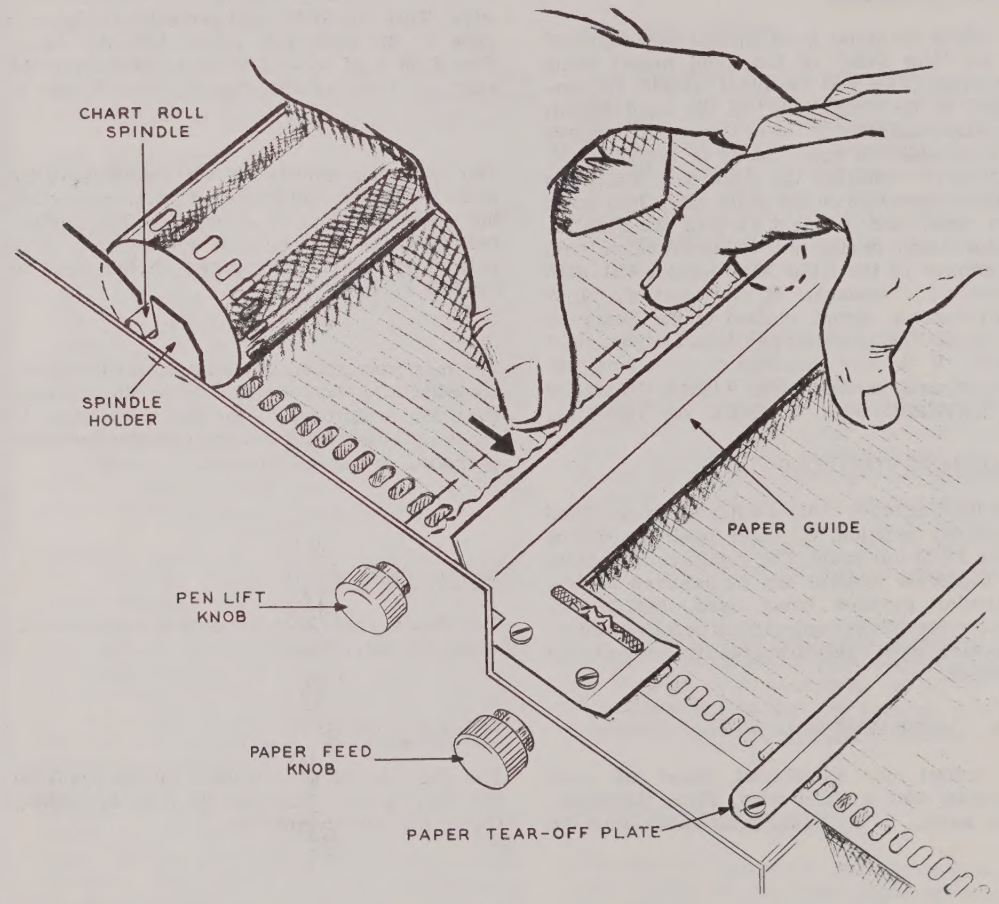


Figure 2

PAPER LOADING (Figure 2)

1. Remove the pen from the pen carriage.
2. Remove the trim plate by lifting it.
3. Remove the chart roll spindle by lifting it straight up and out of the spindle holder. Place the chart roll spindle through the center of the chart paper roll.
4. Replace the chart roll spindle in the spindle holders with the paper positioned so that the paper rolls off the spindle from the bottom as shown in Figure 2.
5. Referring to Figure 2, insert the chart paper under the paper guide and turn the paper feed knob on the side of the Recorder until the perforations on each side mesh with the paper drive sprockets. Feed the paper under the paper tear off plate.
6. Turn the POWER switch to the CHART position and the paper drive sprockets will pull the chart paper under the paper guide.

PEN INSTALLATION (Figure 3)

The pen supplied with the Recorder is a standard fine point cartridge type fountain pen. The pen carriage is designed so that when the Recorder is not in use, the pen can be stored upside down in the pen carriage with the cap on. This keeps the ink from drying on the pen point and prevents the point from being damaged. The pen may be lifted from the paper by turning the pen lift knob on the side of the Recorder.

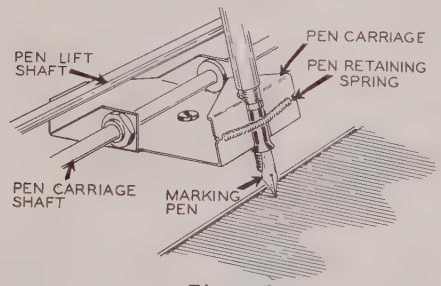


Figure 3

1. To place the marking pen in operation, remove the pen from the pen carriage and remove its cap.

2. Insert the point end of the marking pen into the pen carriage until the concave portion of the pen fits into the pen carriage as shown in Figure 3.

3. If you desire a multi-color recording, this can be done very easily by obtaining locally several pens of the recommended type (see Replacement Parts List) with different color inks. The use of the inexpensive pen makes this feature possible with very little cost, and yet provides a clear, sharp recording.

INTERCHANGEABLE SCALES

Two different scales are provided so that direct readings can be obtained for various spans. These scales slide under the clips as shown in Figure 3A. The one blank scale is provided so that it can be marked as desired.

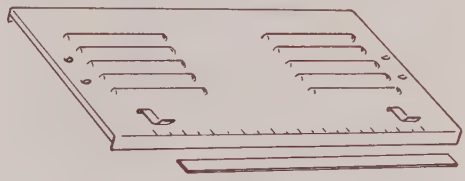


Figure 3A

OPERATIONAL SEQUENCE

1. Place the POWER switch in the STANDBY position and allow a few minutes for warmup.

2. Install the chart paper in the Recorder.

3. Properly adjust the Sensitivity controls.

4. Position the marking pen properly in the Recorder.

5. Lower the pen to the chart paper.

6. Place the POWER switch in the SERVO position.

7. With zero input signal to the input terminals (shorted), adjust the ZERO POSITION control for the desired zero reference point. (For suppressed zero operation, see Page 12).

8. Adjust the DAMPING control.

9. Connect the DC Signal source to the input terminals.

10. If necessary, adjust the HUM ADJ control.

11. Place the POWER switch in the CHART position. The Recorder is now recording the input signal.

APPLICATIONS

The Servo Recorder can be used for many varied functions. It is not possible to discuss here each individual application in detail. The following illustrations and schematics are provided to give examples of some possible uses of the Servo Recorder. Additional uses and information concerning Servo Recorders are available in the book "Electronics For Scientists," by Dr. H. V. Malmstadt and Dr. C. G. Enke.

CONNECTIONS FOR NORMAL RECORDER INPUT CIRCUIT (FIGURES 4A, 4B, AND 4C)

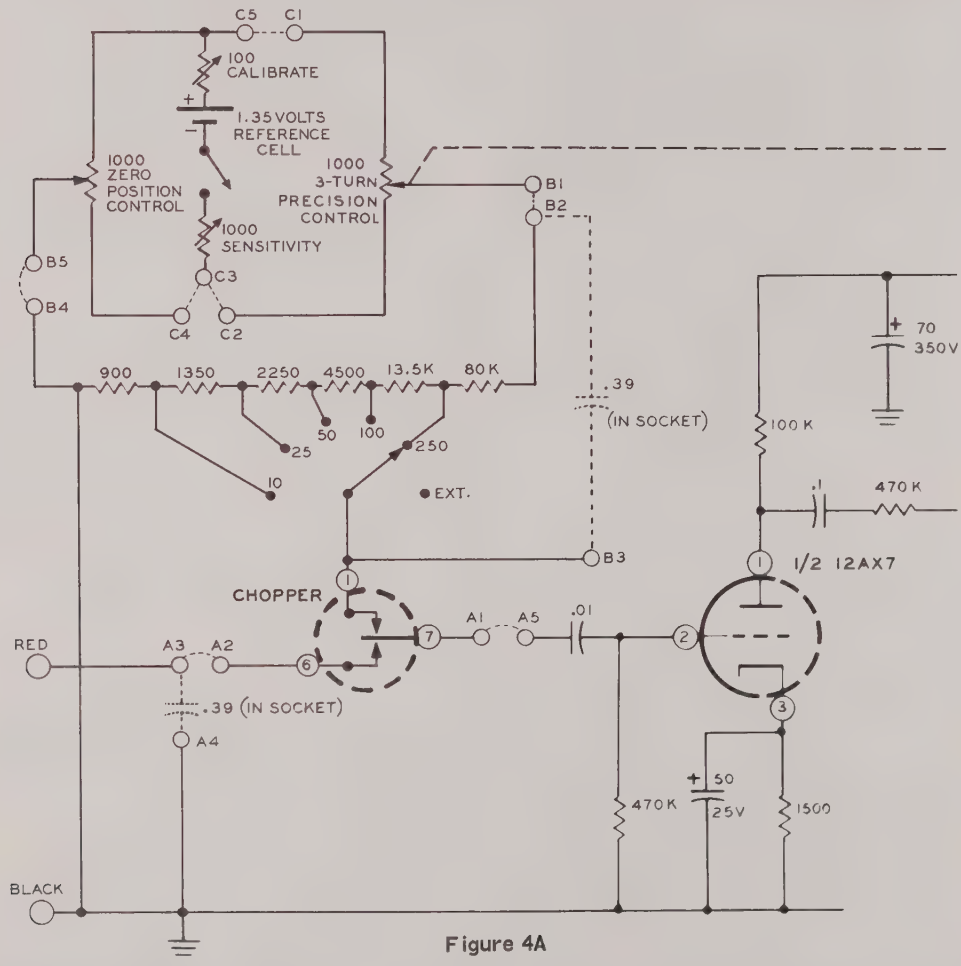


Figure 4A

FIVE-PIN SOCKETS FOR RAPID MODIFICATIONS

The input circuit is shown in Figure 4A. Components and sections of the circuit are connected between the pins on three standard 5-pin plugs. Therefore, the input circuit can be easily reconnected for various functions by changing connections between the pins.

The location of the 5-pin plugs is shown in Figure 4C, and the arrangement of pins is shown in Figure 4B, which is also printed on the back panel of the Recorder. The plugs are labeled A, B, and C, and the corresponding pins are named A1 to A5, B1 to B5, and C1 to C5. The same designations can be seen on the schematic in Figure 4A.

The circuit is connected for its normal operation as a recording potentiometer when the standard sockets A, B, and C are connected to the mating plugs. These sockets contain the interconnecting wires and parts shown by dotted lines in Figures 4A and 4B. To rewire the circuit for other

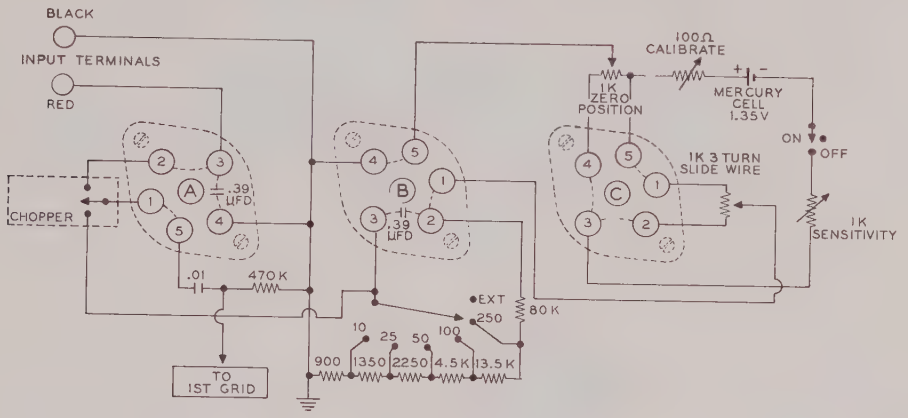


Figure 4B

applications, the necessary 5-pin sockets are removed to expose the plug pins. For experimental circuits, connections can be rapidly made to the plug pins with the special spring-clip parts (resistors, capacitors, leads, etc.) from the EU-13A Universal Experimental Chassis and Parts. In this way the servo potentiometer can be converted in a matter of minutes to a servo constant-current source, a servo potentiostat, or other servo devices.

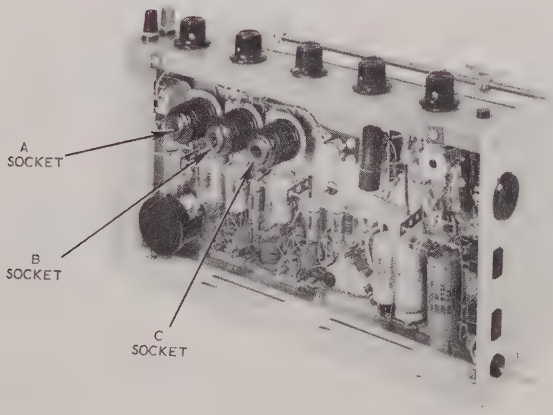


Figure 4C

SERVO CURRENT OR VOLTAGE CONTROLLER

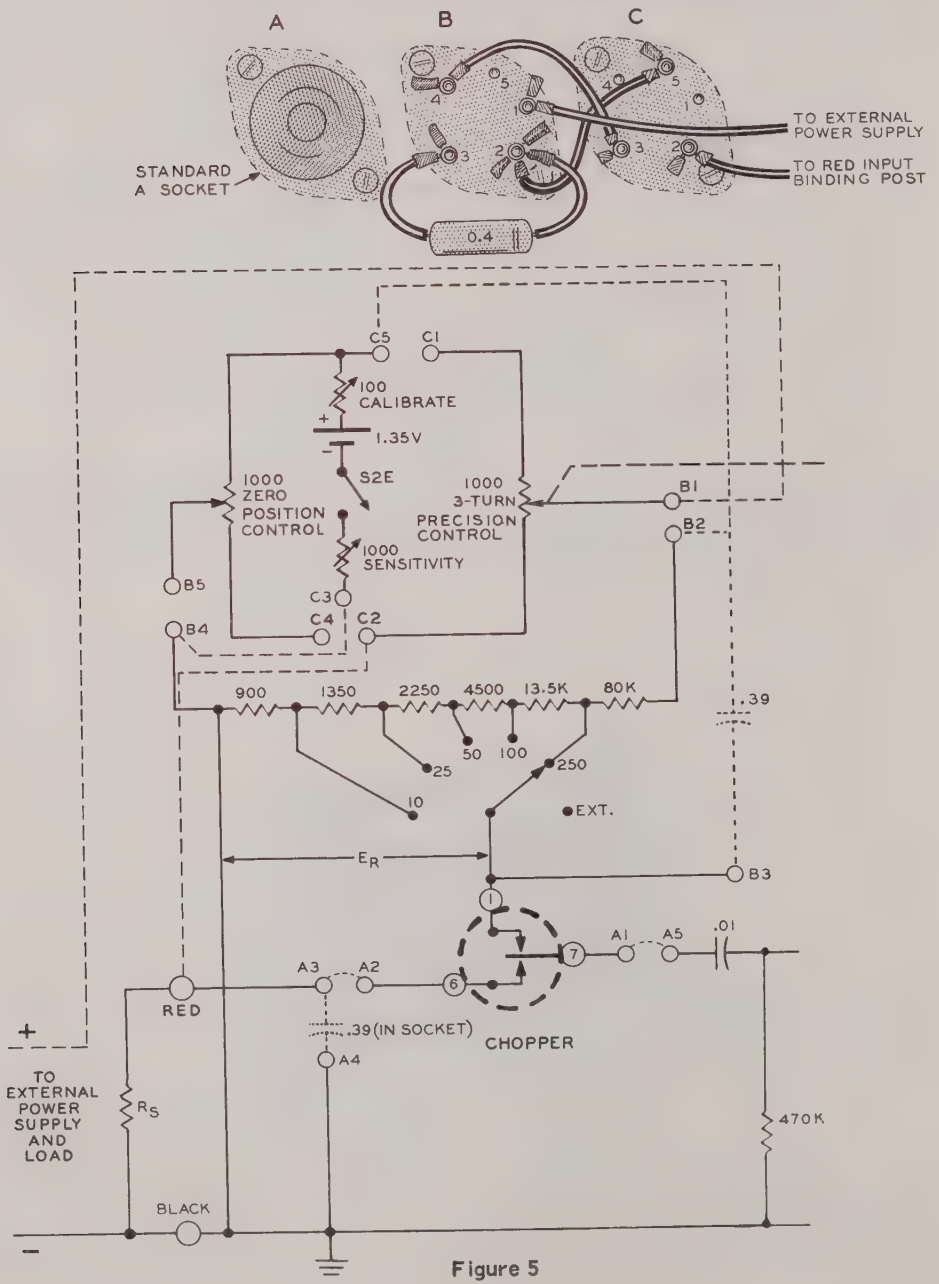


Figure 5

Permanent modules can be wired in suitable chassis and plugged into the back with 5-pin sockets. A series of specific modules would enable rapid changeover from one type of servo device to another.

NOTE: For minimum hum pickup when using plugs A and B, the circuitry should be shielded and the shield connected to pin 4 of the plug.

SERVO CURRENT OR VOLTAGE CONTROLLER

Figure 5 shows the schematic connections so the Recorder can be used as a servo controller for current or voltage. The 3-turn, 1000 Ω control is connected in series with the load and an external power supply as the control element. For current control, a precision resistor, R_S, is also placed in series with the external supply and the load. The terminals of resistor R_S are connected to the input terminals of the Recorder.

The voltage across precision resistor R_S must equal the reference voltage, E_R, for the servo to come to balance. If E_R = 100 mv and R_S = 100 Ω, the current will equal E_R/R_S = 1.00 ma when the servo is at balance. The servo control element will automatically adjust to control the current at 1.00 ma. Other currents can be obtained by changing the reference voltage (use the range selector) or by changing precision resistor R_S.

For voltage control, the points in the circuit which are to remain at the control potential are connected to the input terminals. The 1000 Ω control in the external power supply circuit will adjust the current to the load to keep the control potential equal to ER.

CAUTION: Do not exceed 50 ma through the 3-turn control. Higher currents can be obtained by changing controls or adding another high current control on the extension drive shaft, which is exposed by removing the chart paper plate.

CAUTION: The chassis of the Recorder, the load, and the external power supply may be at different potentials.

WIRING CHANGES TO REVERSE PEN TRAVEL

Turn the Recorder off before proceeding. Figure 6 shows the leads on the servo motor and on socket C reversed from standard connections so that the pen now travels left-to-right with increasing voltage. The two spade lugs on the servo motor are loosened with a screwdriver so that the red and red-yellow leads can be readily interchanged. The interconnecting wires in the standard C socket are reconnected by interchanging the terminals on pins C1 and C2. For temporary or occasional left-to-right operation, the C connections shown in Figure 6 can be made with short spring-clip leads to the plug pins, or a separate C reverse socket could be wired.

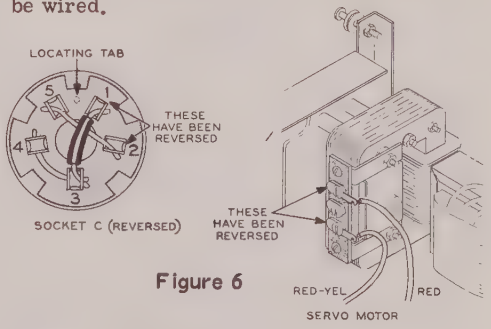


Figure 6

REMOTE OPERATION

To operate the Recorder remotely, the POWER switch must be placed in the STANDBY position to supply power to the Recorder.

In order to switch the Recorder to the SERVO position remotely, it will be necessary to connect the following pins of the 11-pin socket together with an external switch or relay. Refer to the Schematic (fold-out from Page 23).

CONNECT PIN	TO PIN
2	3
5	6
7*	8*
10	11

*If long leads are necessary for these connections, use shielded cable or place a relay close to the 11-pin socket to reduce hum pickup.

To switch the Recorder to the CHART position remotely, connect pin 2 to pin 4 of the 11-pin accessory socket.

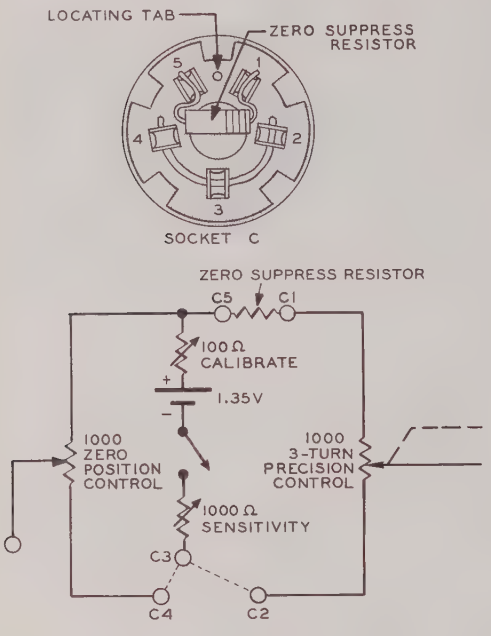


Figure 7A

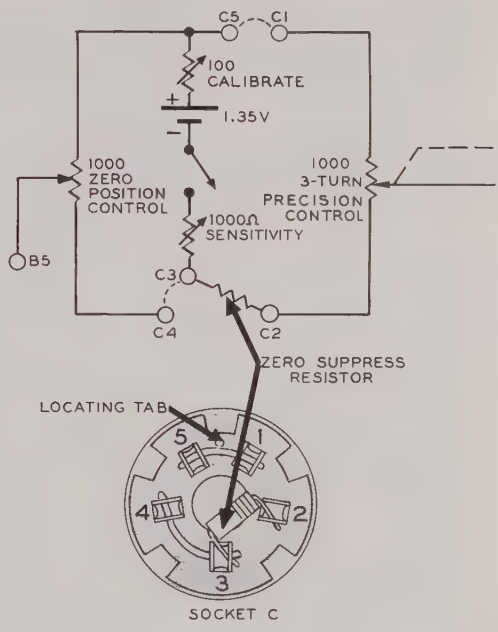


Figure 7B

Refer to the Power Switch section under Operation on Page 4 for voltages available at the 11-pin accessory socket.

NONLINEAR OPERATION

The Recorder can be modified to permit nonlinear recording. This is accomplished by changing the 3-turn measuring slidewire control to one having the correct electrical specifications. Controls of this type are available from various control manufacturers.

ZERO SUPPRESS

Figure 7A shows the C1 to C5 connections that are necessary for zero suppression to the left. Figure 7B shows the wiring changes for zero suppression to the right.

The amount of zero suppression and the chart span depend on the value of the zero suppress resistance. A 1000 Ω resistor would give full-scale zero suppression, and the span would be decreased to one-half the normal calibrated value.

Figure 7C shows how an external voltage can be connected into the Recorder input for additional zero suppression beyond the range of the ZERO POSITION control. The Model EUW-16A Voltage Reference Source provides a wide range of suppression voltages for this application.

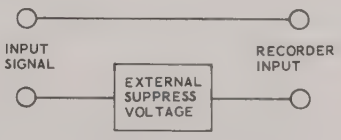


Figure 7C

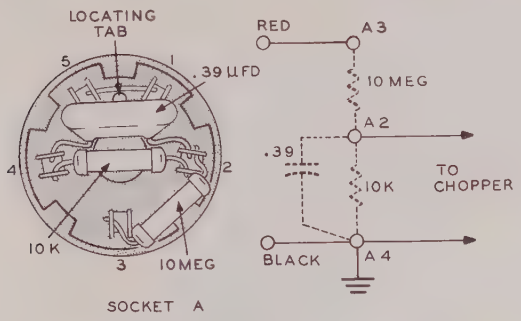


Figure 8A

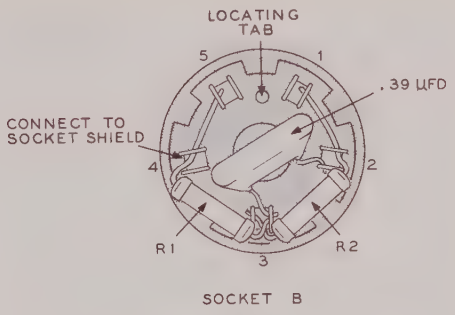


Figure 8B

RECORDING HIGH VOLTAGES

Figure 8A shows a voltage divider at the input which puts only 1/1000 of the signal voltage across the chopper. Therefore, full scale on the normal 100 mv range will now be 100 volts.

EXTERNAL RANGE SOCKET

Special, fixed-calibrated, full-scale sensitivities can be obtained by using external sockets. These sockets are used in place of the standard B socket. The following formula enables you to calculate the resistor values required; the resistors are shown in Figure 8B.

R1 = 90 x (millivolts full scale)

R2 = 102,500 Ω - R1

C1 = .39 µfd, must be low leakage type.

NOTE: R1 and R2 must be precision temperature stable resistors.

RECORDING VOLTAGE AND RESISTANCE RANGES OF A VTVM

All of the voltage ranges on the EUW-24 VTVM can be recorded by connecting the Recorder into the output terminals of the VTVM as shown in Figure 9. Also, all of the resistance ranges of the VTVM can be recorded. Full scale on the Recorder is made to correspond to full scale on the VTVM by switching the Recorder sensitivity switch to the 250 mv position, and then adjusting the Recorder Vernier Sensitivity control with a full-scale signal on the VTVM. The standard sockets A, B, and C should be in the Recorder.

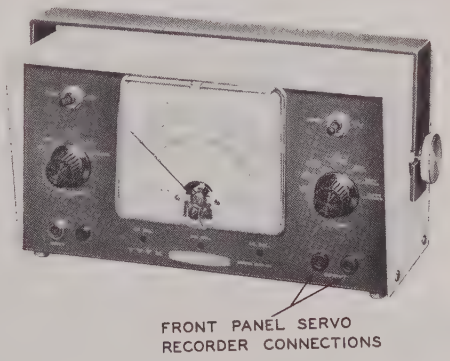


Figure 9

MAINTENANCE

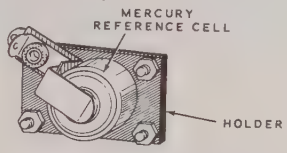
1. LUBRICATION

Proper lubrication of the Recorder, which insures proper operation, should be done at approximately 3-month intervals. One drop of light machine oil should be placed at each point indicated in Figure 10. These points are accessible by removing the chart paper guide plate. This is done by removing the three screws located under the front of the Recorder. The pen carriage shaft should be wiped with a cloth and relubricated.

DO NOT permit any oil to touch the drive cord. This will introduce slippage and cause poor Recorder operation.

2. REFERENCE CELL

The mercury reference cell has a normal life of approximately 300 hours in this application. The cell should be replaced at this time. When the cell is exhausted, the Recorder will not remain in calibration.



To replace the mercury cell, remove the back panel from the Recorder. Remove the cell from its holder. There is an access hole in the front of the chassis that may be used to push the cell from its holder. Replace it with a cell of the same type (NEDA No. 1100).

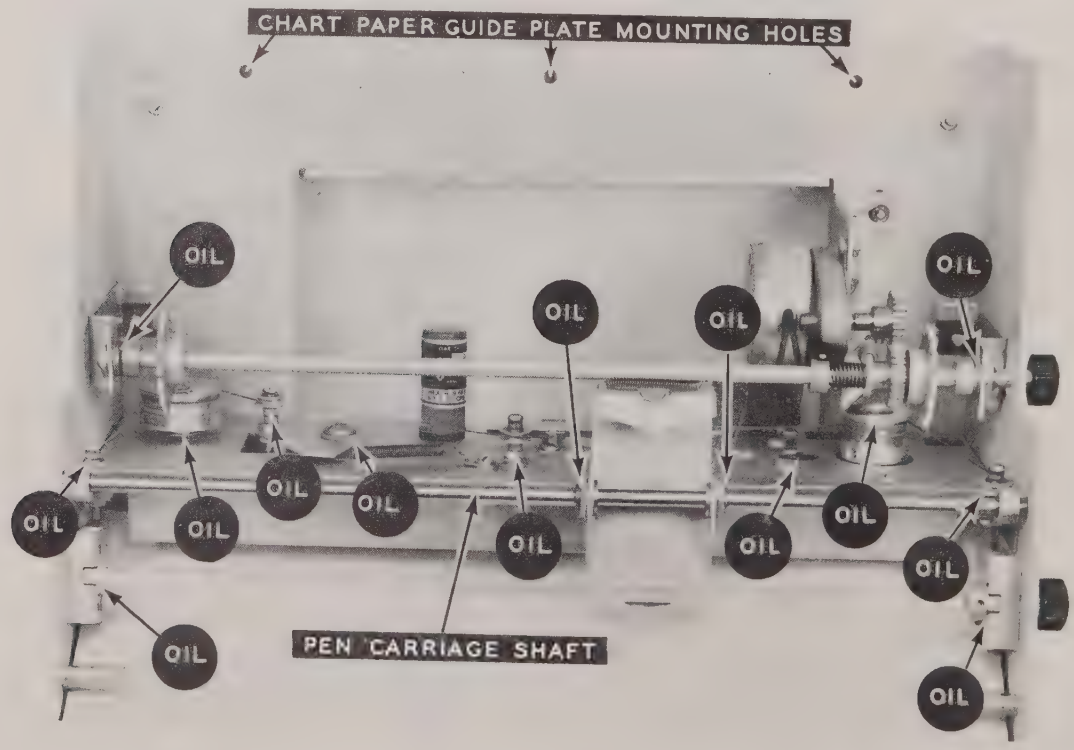


Figure 10

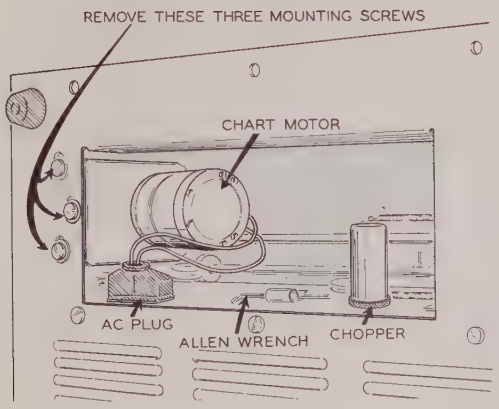


Figure 11

3. CHOPPER AND TUBE REPLACEMENT

Refer to Figure 11 to locate the chopper. To replace the chopper, turn the Recorder on its back and remove the chopper through the hole in the bottom plate.

To replace the tubes, remove the trim plate from the top of the Recorder. The tube types are printed on the chassis.

4. CHART MOTOR CHANGE

No difficulty should be encountered with the chart motor. However, the motor can be interchanged with other motors of the same type to obtain different chart speeds. (See Special Chart Motors on Page 20.)

To change the chart motor, turn the Recorder on its back. Then remove the three screws that secure the motor mounting plate. Refer to Figure 11. Unplug the AC plug and remove the motor from the Recorder. Place the new motor in the Recorder. Slide the motor toward the rear of the Recorder until the gears mesh. Check this by turning the Paper Feed Knob. Now tighten the three mounting screws.

5. 3-TURN CONTROL CLEANING AND REPLACEMENT

The 3-turn control is supplied by the manufacturer completely sealed and lubricated. Should you find it necessary, the control can be cleaned in the following manner:

A. Disconnect the Recorder from the power line and remove the trim plate and the back plate.

B. Remove the control from the Recorder and locate the drive pins securing the rear cover. To remove the pins, insert a sharp knife blade or similar instrument under the pin heads and pry the pins out.

C. Disassemble and clean the control as follows:

(1) Remove the control cap and lift the control wiper-arm contact spring out the top of the control case.

(2) With a lint-free cloth, clean the control case, cap, wiper-arm contacts, spring, and slidewire. CAUTION: Do not scratch or mar the slidewire. A solvent should not be used for cleaning. Do not remove the wiper arm of the control.

After cleaning, lubricate the control with petroleum jelly or similar lubricant. After lubrication, reassemble the control and replace it in the Recorder.

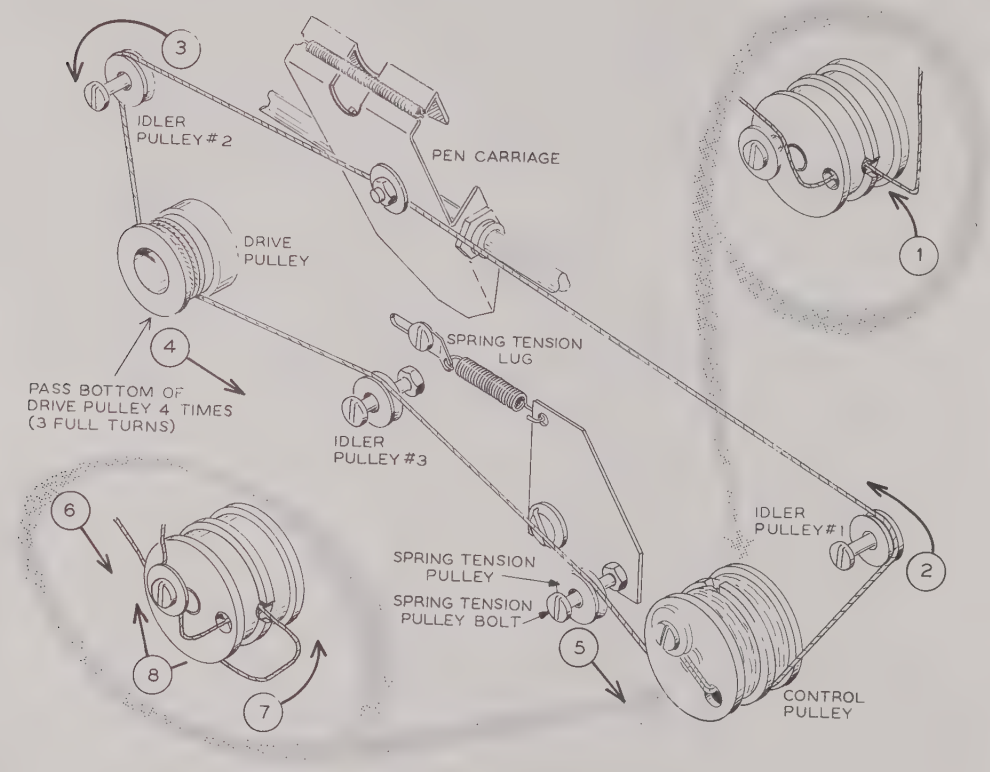


Figure 12

6. DRIVE CORD CARE AND REPLACEMENT

To insure optimum operation of the Recorder, the drive cord must be free of oil, unfrayed, and have proper tension. Refer to Figure 12 for drive cord replacement and proceed as follows.

A. Loosen the screw on the spring tension lug and slide it to the extreme right.

B. Rotate the 3-turn control fully counter-clockwise. The cord hole in the control pulley should be at the 4:30 o'clock position. If the pulley is not in this poistion, loosen the flexible coupling setscrews on the control and rotate the drive shaft. Retighten the setscrews.

C. Place one end of the drive cord through the cord hole and out the front. NOTE: The pulley can be rotated to facilitate this operation, but it must be returned to the full clockwise position to obtain proper drive cord installation. Place the cord under the washer and temporarily tighten the screw.

D. Route the drive cord over idler pulley #1. Rotate the control pulley clockwise a full three turns until it hits the stop. The dial cord should now be wrapped around the control pulley, side by side, on the rear half of the pulley.

E. Route the drive cord around idler pulley #2 and around the drive pulley three complete turns. Be sure that the three turns go from the outside of the drive pulley to the inside.

F. Route the drive cord over idler pulley #3 and the spring tension pulley.

G. Place the drive cord under the control pulley, in the front half, and place the end through the cord hole and out the front.

H. Loosen the screw and place the string under the washer. Pull the string until the tension spring is stretched to the point where the spring tension pulley bolt almost touches the stop. Tighten the screw to secure the string.

I. Run the servo motor from one extreme to the other to be sure the string runs properly on the pulleys and does not bind at any point.

J. Turn the control to the center of its range. (One and one-half turns from either end.)

K. Position the pen carriage at midscale (50).

L. Slip the drive cord under the rear of the pen carriage washer and tighten the screw.

M. Rotate the servo motor by hand and be sure that the pen carriage hits its stops before the control hits its stops.

N. Adjust the spring tension pulley as described in the Adjustments section.

ADJUSTMENTS

The following adjustments are made at the factory before the unit is shipped. However, if difficulty is encountered, or if maintenance work is performed, it may be necessary for you to readjust some of these points. An allen wrench is furnished to make these adjustments. (See Figure 11.) The following procedure should be used.

PAPER AND PEN ALIGNMENT

It is very important that the paper be fed through the Recorder evenly. This is a function of the paper drive sprockets. These sprockets should be set in the center of the slot in the chart paper drive plate. The teeth on both sprockets should be in line. If they are not in line, and one side pulls the chart paper before the other, loosen the setscrews in the right-hand sprocket and reset the sprocket on the shaft. Then retighten the setscrews. If the left-hand sprocket is not centered in the chart paper drive plate, it is necessary to loosen the collar on the left side of the sprocket shaft to remove spring tension, then adjust the position of the sprocket. The lines on the chart paper should now be parallel to the paper guide. Compress the spring and retighten the collar.

After chart paper alignment has been accomplished, start the paper through the Recorder. Stop the Recorder and move the pen across the chart paper. The pen should follow parallel to the chart paper grid lines. If it does not, loosen the screw in either end of the pen carriage shaft and move the shaft in the proper direction until the pen follows the grid lines on the chart paper.

SPROCKET HEIGHT ADJUSTMENT

It is important that the sprockets be high enough to mesh properly in the sides of the chart paper. This adjustment can be made by loosening the drive shaft mounting brackets screws and turning sprocket height adjustment screws. See Figure 1. Retighten the mounting bracket screws. Proper mesh is obtained when the sprocket teeth just fill the holes in the paper.

PEN LIFT ADJUSTMENT

Turn the Pen Lift Knob until the flats of the pen lift shaft are horizontal (See Figure 1). In this position, with the pen touching the chart paper, the pen carriage should clear the flat of the pen lift shaft by 1/64" when the pen carriage is moved from one side to the other. This can be adjusted by loosening the screws in the side of the Recorder and adjusting the pen lift shaft brackets.

PEN CARRIAGE STOP ALIGNMENT

Proper adjustment of the pen carriage stops will be indicated by the end positions of the pen carriage. The pen carriage should stop with the pen off-scale (approximately 1/16") on the chart paper but at a safe distance from the edge of the paper guide plate. This adjustment is made by loosening the setscrews in the pen carriage stops and moving them to the proper position to satisfy the above conditions.

DRIVE CORD TENSION

The drive cord tension should be set so that there is even drive for both directions of pen travel. The drive cord tension can be set by loosening the screw on the drive cord spring tension lug and moving it to the left to increase tension.

IN CASE OF DIFFICULTY

SYMPTOM	POSSIBLE CAUSE	REMEDY
Pen will not overshoot with DAMPING control in full counterclockwise position. Input short-circuited on High range.	1. Defective tube. 2. Poor chopper action.	1. Replace tube. 2. Replace chopper.
Non-uniform pen speed through full range of travel.	1. Pen carriage binding on shaft. 2. Drive cord tension insufficient. 3. Bind in mechanical system.	1. Clean shaft. 2. Adjust tension. 3. Eliminate bind by cleaning, adjusting and lubricating.
Pen travels faster in one direction than in other.	1. Balancing signal has non-symmetrical waveform due to poor chopper. 2. Drive cord tension insufficient. 3. Improper hum adjustment.	1. Replace chopper. 2. Adjust tension. 3. Reset the HUM ADJ control.
Poor sensitivity, large dead zone.	1. Pen carriage binding on shaft. 2. Drive cord tension insufficient. 3. Bind in mechanical system. 4. Stray AC pickup. 5. Low amplifier gain. 6. Excessive source resistance. 7. Excessive drive cord tension. 8. Low reference cell voltage. 9. Servo motor dirty. 10. Excessive hum in signal source.	1. Clean shaft. 2. Adjust tension. 3. Eliminate bind by cleaning, adjusting, and lubricating. 4. Check grounding for AC on input signal. 5. Check tubes for gain and noise. 6. Insure source resistance is less than 50 KΩ. 7. Adjust tension. 8. Replace reference cell. 9. Remove motor, clean gears, and lubricate shafts. 10. Eliminate hum in signal source or try to cancel out with HUM ADJ in control.

SYMPTOM	POSSIBLE CAUSE	REMEDY
Calibration drifts, instrument will not calibrate.	1. Low voltage from reference cell.	1. Replace reference cell.
Pen moves to extreme position of pen travel and stays there.	1. Open circuit in input system. 2. Reference cell not in place. 3. Extremely low reference cell voltage. 4. Chopper malfunction. 5. Reversing of pen travel not performed properly.	1. Check external connections. 2. Check connections to cell. 3. Replace reference cell. 4. Replace chopper. 5. Check for reversed motor leads or reversed C socket leads.
Pen oscillates at any position of DAMPING control.	1. Loose motor pulley or 3-turn control pulley, or flexible coupling.	1. Tighten pulleys or coupling.
Repeated pen "jitter" at same point on chart.	1. Dirty 3-turn control.	1. Clean 3-turn control.

REPLACEMENT PARTS

This list includes only these parts which may be difficult to obtain locally in case a replacement is needed.

PART No.	DESCRIPTION
RESISTOR-1% 1/2 WATT	
2-29	900 Ω
2-177	2250 Ω
2-176	4500 Ω
2-153	1350 Ω
2-155	13.5 KΩ
2-124	80 KΩ
CAPACITORS	
27-50	.39 μfd Mylar*
25-43	70 μfd 350 V electrolytic
25-57	100 μfd 200 V electrolytic
25-104	200 μfd 25 V electrolytic
CONTROLS-SWITCHES	
10-61	200 Ω tab-mount control
10-158	1000 Ω 10-turn control
11-48	1000 Ω 3-turn precision linear control
63-344	Rotary switch (Range)
63-317	Rotary switch (Power)
TUBES-RECTIFIERS	
411-26	12AX7/ECC83 tube
411-108	6BQ5/EL84 tube
57-27	500 ma 500 PIV silicon rectifier
MISCELLANEOUS	
51-99	Output transformer
54-152	Power transformer

*DuPont Registered Trademark

PART No.	DESCRIPTION
Miscellaneous (cont'd.)	
68-9	Chopper
260-32	Spring clip
349-1	Dial cord, 5 feet
406-23	Sheaffer cartridge fountain pen with 304 point (or equivalent)
412-15	Neon lamp for clear lens
412-36	Neon lamp for red lens
413-11	Neon lamp lens (clear)
413-10	Neon lamp lens (red)
445-12	Blank scale
445-12-1	250 to 0 scale
418-10	Mercury cell (NEDA No. 1100)
420-22	Servo motor
420-43	Chart motor for EUW-20A, 60 cps operation, 1/2 rpm (2" per minute)
420-50	Chart motor for EUW-20AE, 50 cps operation, 1/2 rpm (2" per minute)
421-23	1 ampere slow-blow fuse
445-8	Roll chart paper
451-15	Clutch drive gear
451-38	Motor gear
451-36	Paper drive sprocket
453-119	Pen carriage shaft
462-52	Large knob
462-108	Small knob
266-77	Pen carriage
406-44	Dust cover
595-789	Manual

SPECIAL CHART MOTORS

For special chart speeds, the following additional motors can be purchased from Heath Company. The motors come premounted on a motor mounting plate and with the drive gear already on the motor shaft. These are for 60 cps operation. 50 cps motors are available on special order. The method of installing chart motors is shown in Figure 11.

NOTE: Replacement chart paper is available from Heath Company as part number 445-8.

CHART SPEED	MOTOR MODEL NUMBER
2 inches/hour	EUA-20-10
6 inches/hour	EUA-20-2
12 inches/hour	EUA-20-3
30 inches/hour	EUA-20-4
1 inch/minute	EUA-20-5
4 inches/minute	EUA-20-6
5 inches/minute	EUA-20-7
8 inches/minute	EUA-20-8
12 inches/minute	EUA-20-9

Replacement motors for other chart speeds can be purchased from Cramer Division, Gianini Controls Corporation, Old Saybrook, Connecticut. These motors do not come equipped with a drive gear or mounting plate. Give the following information if you order a motor from Cramer.

Type - 117 P.
Power Requirements - 115 volts AC, 50 or 60 cps (specify the frequency).
Shaft Rotation - Counterclockwise as viewed from the shaft end.
Shaft Dimensions - 1/4" diameter, 3/4" length (extending from motor).

RPM - Use this formula.

$$\text{RPM} = \frac{\text{chart speed (inches per minute)}}{4}$$

240 VOLT OPERATION

The Servo Recorder power transformer can be wired for either 120 or 240 volt operation.

Figure 13 shows the 5-lug terminal strip wiring for both 120 and 240 volt operation. To change the transformer from 120 to 240 volt operation perform the following steps.

1. Remove the jumper wire from between lugs 1 and 2 of the 5-lug terminal strip.
2. Remove the jumper wire from between lugs 3 and 4 of the 5-lug terminal strip.
3. Connect a jumper wire between lugs 2 and 3 of the 5-lug terminal strip.

The power transformer is now wired for 240 volt operation.

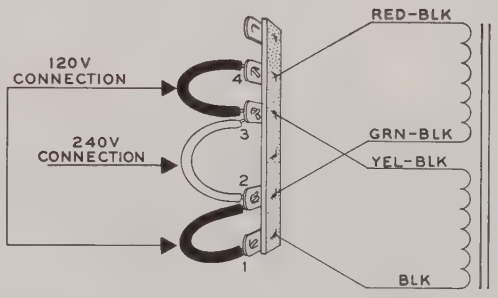
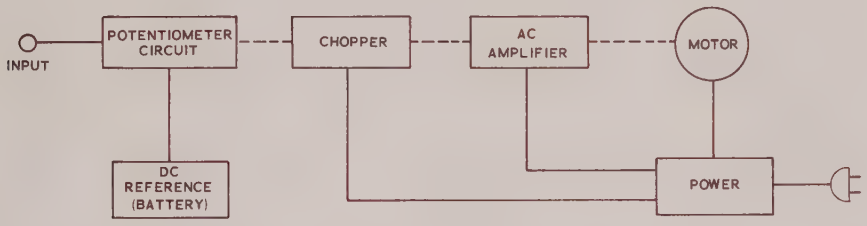


Figure 13



Follow the circuit on the main Schematic and Block Diagrams while reading the following Circuit Description. This description is divided into sections that match the individual circuits of the Recorder. Simplified Schematic Diagrams for each circuit section are provided in the Circuit Description.

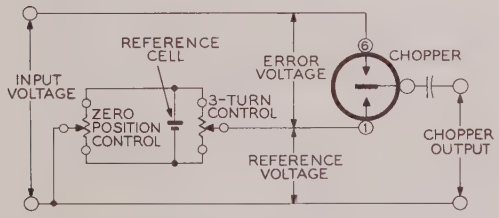


Figure 14

SELF-BALANCING POTENTIOMETER CIRCUIT (Figure 14)

The ZERO POSITION control sets the marking pen at the desired point on the chart paper with zero input voltage (input shorted). Under these conditions the measuring slidewire is automatically adjusted by the servo motor to produce a zero reference voltage. This results in zero AC output voltage from the chopper, which is the balanced condition.

The actual reference voltage is made variable by a voltage divider network consisting of the Range switch, vernier controls, and the precision resistors. The voltage divider circuit is not shown in the simplified schematic.

When a DC voltage is applied to the input terminals, it is compared with the reference voltage by switching back and forth between the two with the chopper. The difference between these two voltages, called the error voltage, appears as a DC voltage at the input to the chopper and as an AC voltage at the output of the chopper. The potentiometer circuit is automatically balanced again to produce zero error voltage. The error voltage or signal, is then applied through amplifier circuits to the servo motor.

The signal causes the servo motor to turn in the proper direction to adjust the measuring slidewire control the proper amount to cancel the error voltage. When the servo motor turns, it moves the marking pen, thus the movement is recorded on the chart paper. At balance, the reference voltage is equal to the input voltage, therefore, the marking on the chart paper directly indicates the amount of input signal.

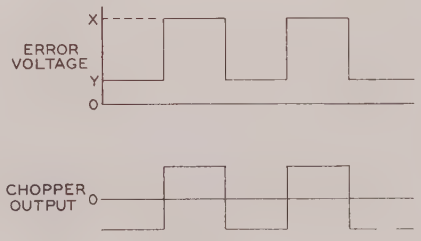


Figure 15

The chopper, in comparing the reference voltage to the DC input voltage, produces the AC voltage required to operate the servo motor. The field of the chopper is connected to a 6.3 volt, 60 cps AC voltage; this causes the contacts to switch at a 60 cps rate. For example, during the time that the movable contact is at position 6 (see Figure 14), the DC input voltage X (see Figure 15) is applied to the .01 μfd capacitor in the output of the chopper circuit. When the movable contact of the chopper is at position 1, the reference voltage Y is applied to the .01 μfd capacitor. This procedure, which occurs at a 60 cps rate produces a 60 cps square wave signal.

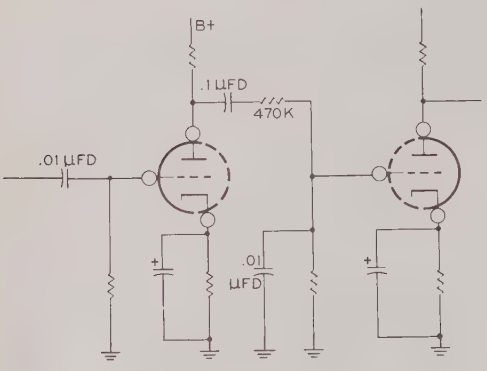


Figure 16

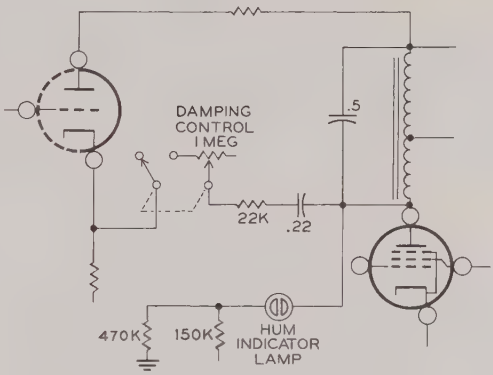


Figure 17

The square wave signal passes through the .01 µfd capacitor which removes the DC component, leaving an alternating signal that varies above and below the zero reference level. The polarity of the DC error voltage to the chopper determines the phase of the square wave output of the chopper.

AMPLIFIER CIRCUIT (Figure 16)

The 60 cps square wave output of the chopper circuit is applied through the .01 µfd capacitor to the grid of the first amplifier. Here the square wave is amplified and coupled through the .1 µfd coupling capacitor and 470 KΩ series resistor to the grid of the second amplifier stage.

Wave shaping circuits are located in the grid circuits of the second, third, and fourth voltage amplifiers, and in the power amplifier. These circuits consist of a .01 µfd bypass capacitor and the 470 KΩ series resistor. When the square wave signal passes through the amplifiers and shaping circuits, the corners are rounded until the square wave becomes a much amplified sine wave. This sine wave is then applied to the power amplifier circuit.

In the power amplifier, the signal is amplified and applied by means of a 60 cps resonant circuit to the control winding of the servo motor. The resonant circuit provides additional shaping of the signal. The servo motor is a 2-phase motor, with line voltage applied to one winding. The direction that the servo motor rotates depends on the phase of the applied sine wave signal from the amplifier, with respect to the phase of the line voltage.

IMPEDANCE-REDUCTION DAMPING CIRCUIT (Figure 17)

A small amount of the signal at the plate of the power amplifier circuit is coupled by the .22 µfd capacitor, the 22 KΩ resistor, and the DAMPING control to the cathode of the preceding voltage amplifier. This signal is 180 degrees out-of-phase with the incoming signal, thus it acts as negative feedback. This negative feedback lowers the impedance of the output stage, giving the power amplifier greater control over the servo motor. This greater control reduces the amount of overshoot as the potentiometer circuit reaches zero. The negative feedback also produces a slight reduction of gain in the voltage amplifier.

The neon hum indicator lamp is biased by a voltage divider network to a point where a small signal at the plate of the power amplifier will cause it to glow. It is therefore normal for the hum indicator to glow while the servo is seeking a null.

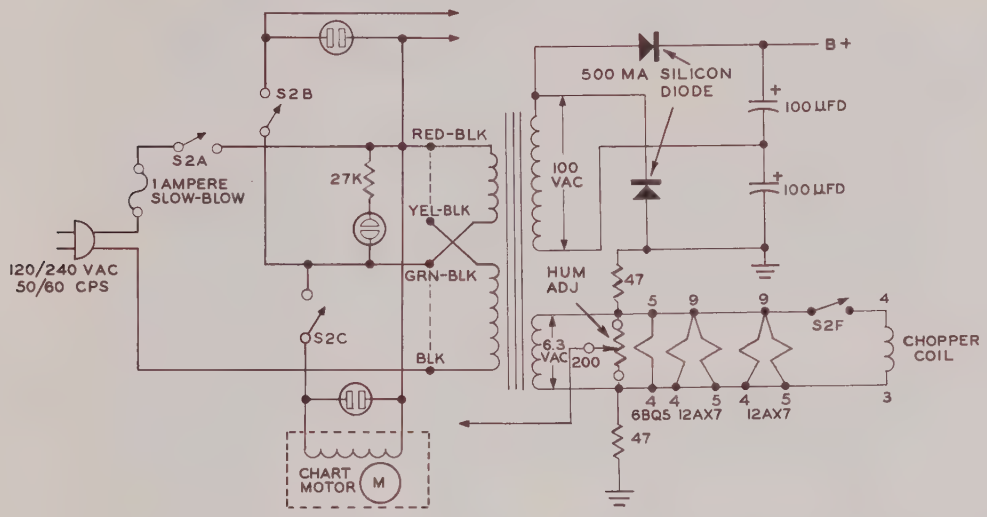


Figure 18

POWER SUPPLY (Figure 18)

The power supply of the Recorder is a conventional full-wave voltage-doubler circuit. A separate winding on the power transformer supplies the filament and chopper coil voltage for the Recorder.

Wide range hum adjustment is provided by the Hum Adjust control by applying an AC hum cancelling voltage of the correct amplitude and phase to the cathode of the fourth voltage amplifier.

MECHANICAL

The servo motor is mechanically coupled by the drive cord to the measuring slidewire control. The drive cord also is attached to the marking pen carriage. As the servo motor rotates to move the measuring slidewire control, the pen carriage moves, and the amount of movement is recorded on the chart paper.

The chart paper is fed through the Recorder by two motor driven sprockets that mesh with the perforations in the edges of the chart paper. The motor speed and gearing of the sprockets determine the chart speed.

REPLACEMENT PARTS PRICE LIST

PART No.	PRICE Each	DESCRIPTION
RESISTORS-1% 1/2 Watt		
2-29	.20	900 Ω
2-177	.40	2250 Ω
2-176	.40	4500 Ω
2-153	.20	1350 Ω
2-155	.20	13.5 KΩ
2-124	.20	80 KΩ
CAPACITORS		
27-50	1.80	.39 μfd Mylar
25-43	1.15	70 μfd 350 V electrolytic
25-57	.95	100 μfd 200 V electrolytic
25-104	.85	200 μfd 25 V electrolytic
CONTROLS-SWITCHES		
10-61	.35	200 Ω tab-mount control
10-158	1.15	1000 Ω 10-turn control
11-48	15.00	1000 Ω 3-turn precision linear control
63-344	1.30	Rotary switch (Range)
63-317	1.90	Rotary switch (Power)
TUBES-RECTIFIERS		
411-26	1.20	12AX7/ECC83 tube
411-108	1.15	6BQ5/EL84 tube
57-27	.60	500 ma 500 PIV silicon rectifier
MISCELLANEOUS		
51-99	3.35	Output transformer
54-152	4.40	Power transformer
68-9	16.30	Chopper
260-32	.45	Spring clip
349-1	.05/ft	Dial cord, 5 feet
406-23	1.00	Sheaffer cartridge fountain pen with 304 point (or equivalent)

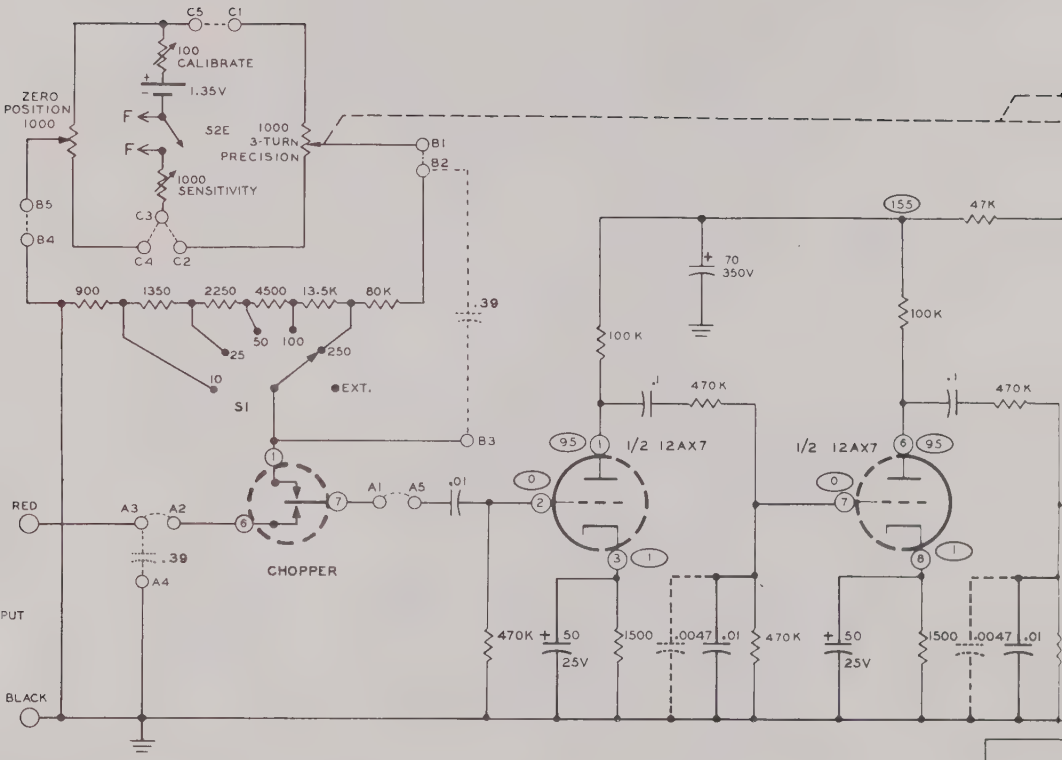
PART No.	PRICE Each	DESCRIPTION
Miscellaneous (cont'd.)		
412-15	.15	Neon lamp for clear lens
412-36	.20	Neon lamp for red lens
413-11	.10	Neon lamp lens (clear)
413-10	.10	Neon lamp lens (red)
445-12	.15	Blank scale
445-12-1	.15	250 to 0 scale
418-10	1.30	Mercury cell (NEDA No. 1100)
420-22	23.65	Servo motor
420-43	5.00	Chart motor for EUW-20A, 60 cps operation, 1/2 rpm (2" per minute)
420-50	5.00	Chart motor for EUW-20AE, 50 cps operation, 1/2 rpm (2" per minute)
421-23	.30	1 ampere slow-blow fuse
451-15	.80	Clutch drive gear
451-38	2.05	Motor gear
451-36	1.05	Paper drive sprocket
453-119	1.00	Pen carriage shaft
462-52	.20	Large knob
462-108	.15	Small knob
266-77	.40	Pen carriage
406-44	1.45	Dust cover
595-789	N/C	Manual

EUW-20 CHART PAPER PRICES (EUA-445-8)

Quan.	Price ea.
1-9 rolls	$4.50
10-24 rolls	$4.25
25-99 rolls	$3.75
100-199 rolls	$3.25
200-500 rolls	$2.75

Write for prices on orders exceeding 500 rolls.

The above prices apply only on purchases from the Heath Company where shipment is to a U.S.A. destination. Selling prices elsewhere in U.S.A. may be slightly higher to offset transportation and local taxes. Outside the U.S.A. parts and service are available from your local Heathkit source and will reflect additional transportation, taxes, duties and rates of exchange.



SCHEMATIC OF THE HEATH SCIENCE SERIES SERVO - RECORDER MODEL EUW-20A

NOTES:

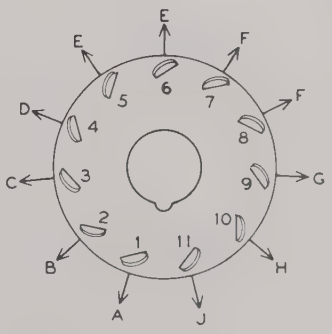
S1 = RANGE SWITCH
S2 = POWER SWITCH
S2A CLOSES IN STANDBY POSITION
S2B, D, E, F CLOSES IN SERVO POSITION
S2C CLOSES IN CHART POSITION
11-PIN ACCESSORY SOCKET VIEWED FROM INSIDE CHASSIS
ALL RESISTORS ARE 1/2 WATT UNLESS SHOWN OTHERWISE.
ALL RESISTOR VALUES ARE IN 1, 1 K = 1000, 1 MEG = 1,000,000 Ω.

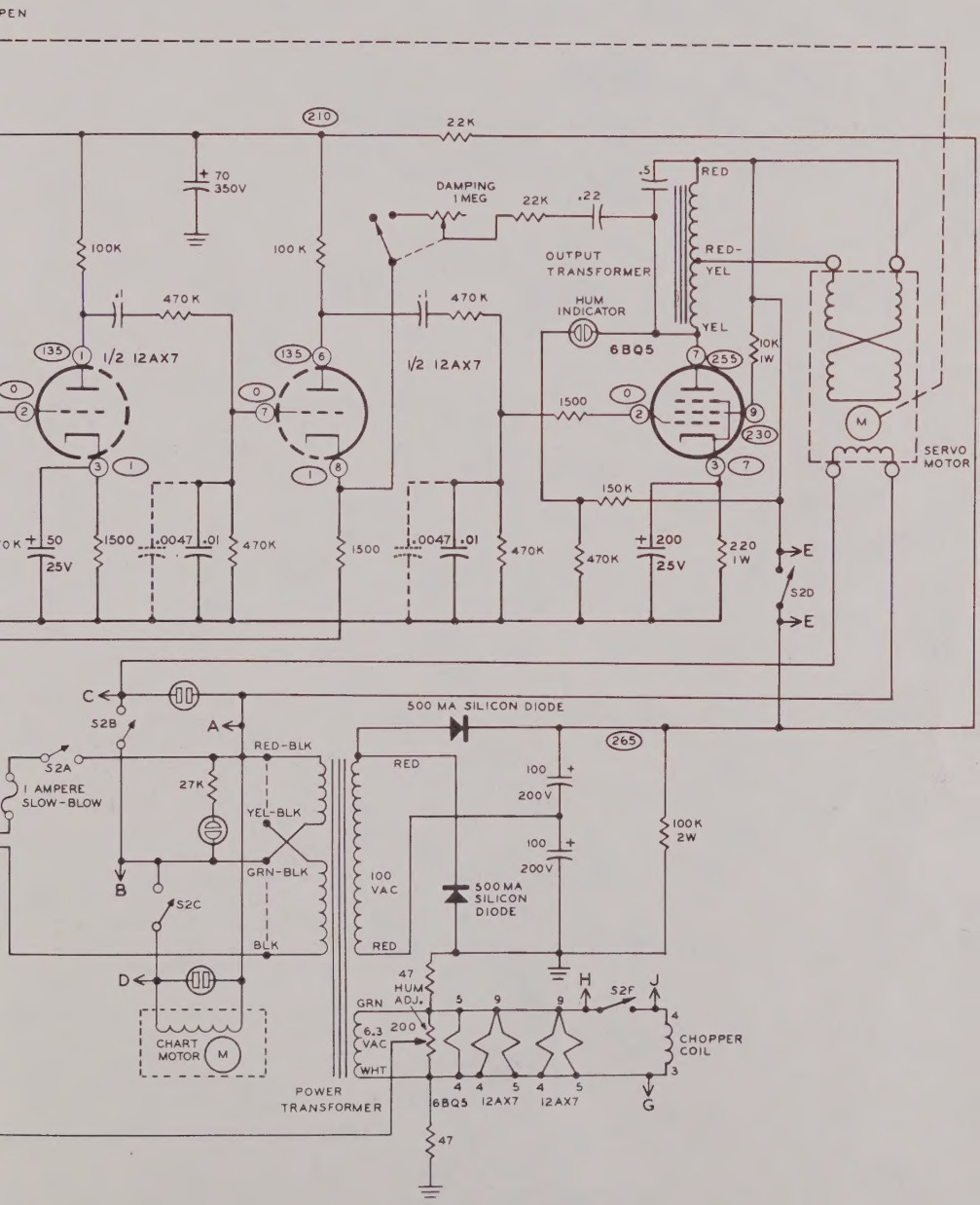
ALL CAPACITOR VALUES ARE IN μfd.

⬭ INDICATES A VOLTAGE MEASUREMENT FROM POINT INDICATED TO CHASSIS EXCEPT FOR AC VOLTAGES ON THE POWER TRANSFORMER.

VOLTAGE READINGS TAKEN WITH AN 11 MEGOHM INPUT VTVM WITH THE CIRCUIT CONNECTED AS SHOWN. INPUT SHORTED, SYSTEM BALANCED, SERVO POWER ON.

CAPACITORS SHOWN WITH DOTTED LINES ARE FOR 50 CPS OPERATION ONLY.




PEN
210
22K
+ 70
350V
DAMPING
1 MEG
22K
.22
.5
RED
100K
100 K
OUTPUT
TRANSFORMER
RED-
YEL
470 K
470 K
HUM
INDICATOR
YEL
6BQ5
10K
1W
135
1/2 12AX7
135
1/2 12AX7
1500
255
230
SERVO
MOTOR
150 K
+ 50
25V
1500
.0047
.01
470K
1500
.0047
.01
470K
470K
+ 200
25V
220
1W
E
S2D
E
C
S2B
A
500 MA SILICON DIODE
265
S2A
RED-BLK
RED
100
200V
1 AMPERE
SLOW-BLOW
27K
YEL-BLK
100K
2W
100
200V
B
GRN-BLK
100
VAC
500 MA
SILICON
DIODE
S2C
BLK
RED
D
47
HUM
ADJ.
H
S2F
J
GRN
5
9
9
4
CHART
MOTOR
M
6.3
VAC
200
CHOPPER
COIL
WHT
3
4 4 5 4 5
6BQ5 12AX7 12AX7
G
POWER
TRANSFORMER
47

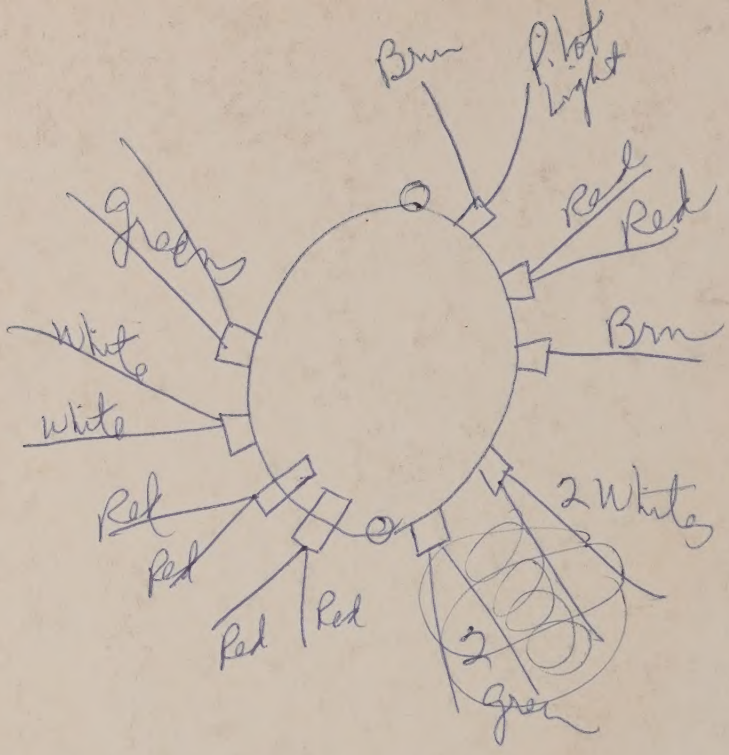
WARRANTY

The Heath Company warrants that under conditions of normal use and service it will repair or replace any factory assembled unit whose performance does not meet published specifications and is returned to Heath prepaid within one year following date of shipment. The published specifications are those labelled "specifications" in the catalog and the manual for the unit. The replacement or repaired unit is shipped prepaid by us anywhere in the continental United States or to APO or FPO addresses. Shipments to other places are FOB factory. Heath's obligation is limited to such replacement or repair by Heath, and Heath is not responsible under this warranty or otherwise for any consequential damage or other loss in connection with the unit or its use.

Questions relating to repairs or warranty replacement in the continental United States (APO and FPO included) should be addressed to Heath Company, attention: Customer Relations, or the nearest Heathkit Electronic Center. In all other areas please contact the authorized Heathkit representative in your country, or Heath Company, attention: International Division.

HEATH COMPANY
Benton Harbor, Michigan 49022

The Heath Company reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to incorporate new features in instruments previously sold.



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